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(54) **FIXING DEVICE AND IMAGE FORMING APPARATUS**

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G03G 15/20 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/2085*** (2013.01); *G03G 15/2053* (2013.01); *G03G 15/2075* (2013.01); *G03G 2215/2032* (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/20
USPC 399/323
See application file for complete search history.

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(57) **ABSTRACT**

A fixing device includes a first roller contacting a fixing belt to generate a rotation friction force therebetween to rotate the fixing belt and a second roller contacting the fixing belt to exert a first inhibition force to the fixing belt in a direction opposite a direction of rotation of the fixing belt. A separation aid is disposed downstream from a fixing nip formed between the fixing belt and a pressure rotator in the direction of rotation of the fixing belt to decrease a curvature of the fixing belt and exert a second inhibition force to the fixing belt in the direction opposite the direction of rotation of the fixing belt. The second inhibition force is added to the first inhibition force to obtain a combined inhibition force that is smaller than the rotation friction force between the fixing belt and the first roller.

19 Claims, 4 Drawing Sheets

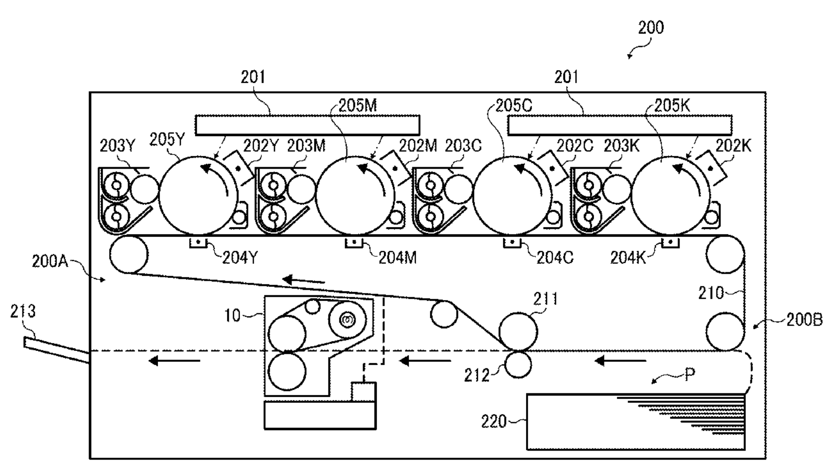

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FIG. 1

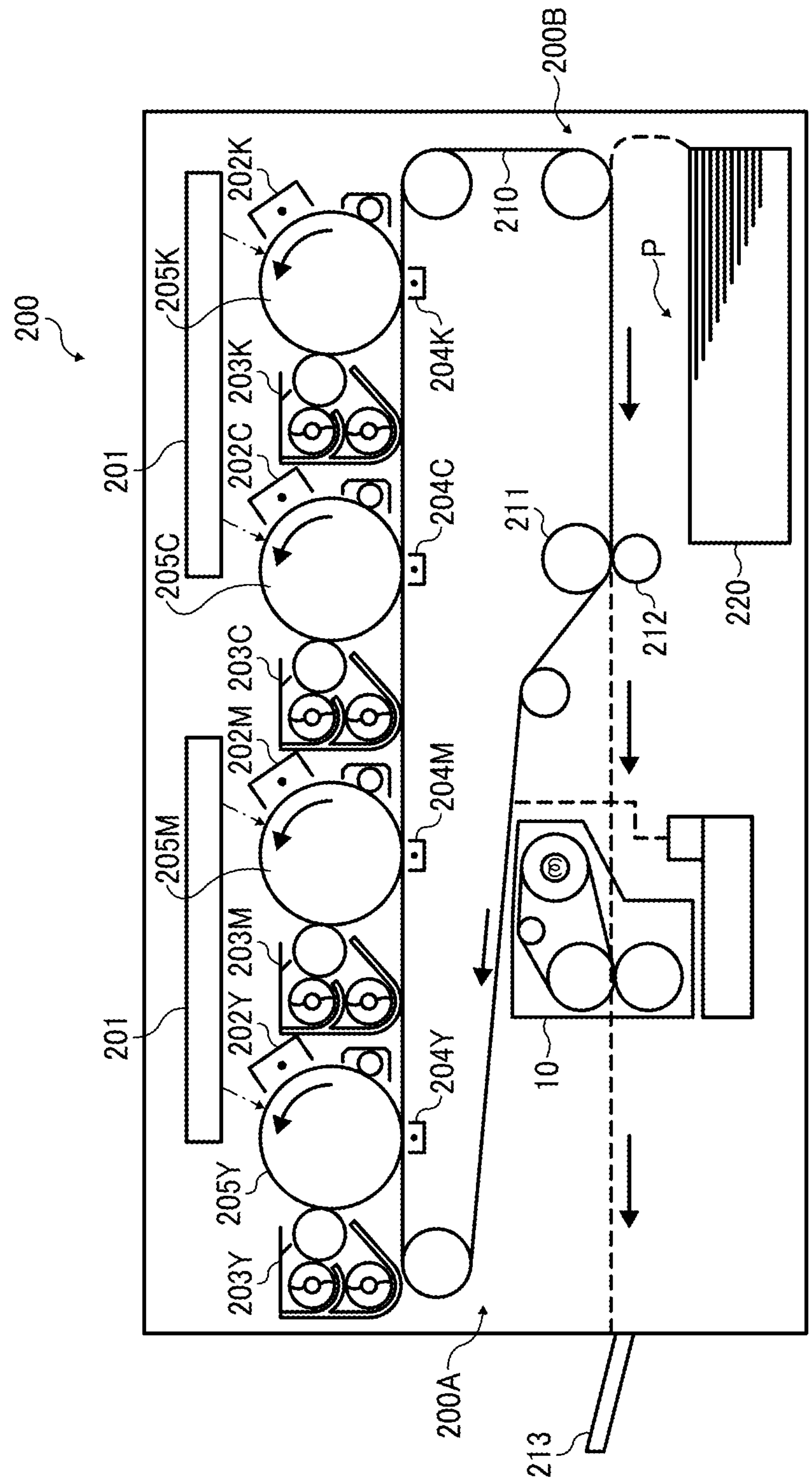
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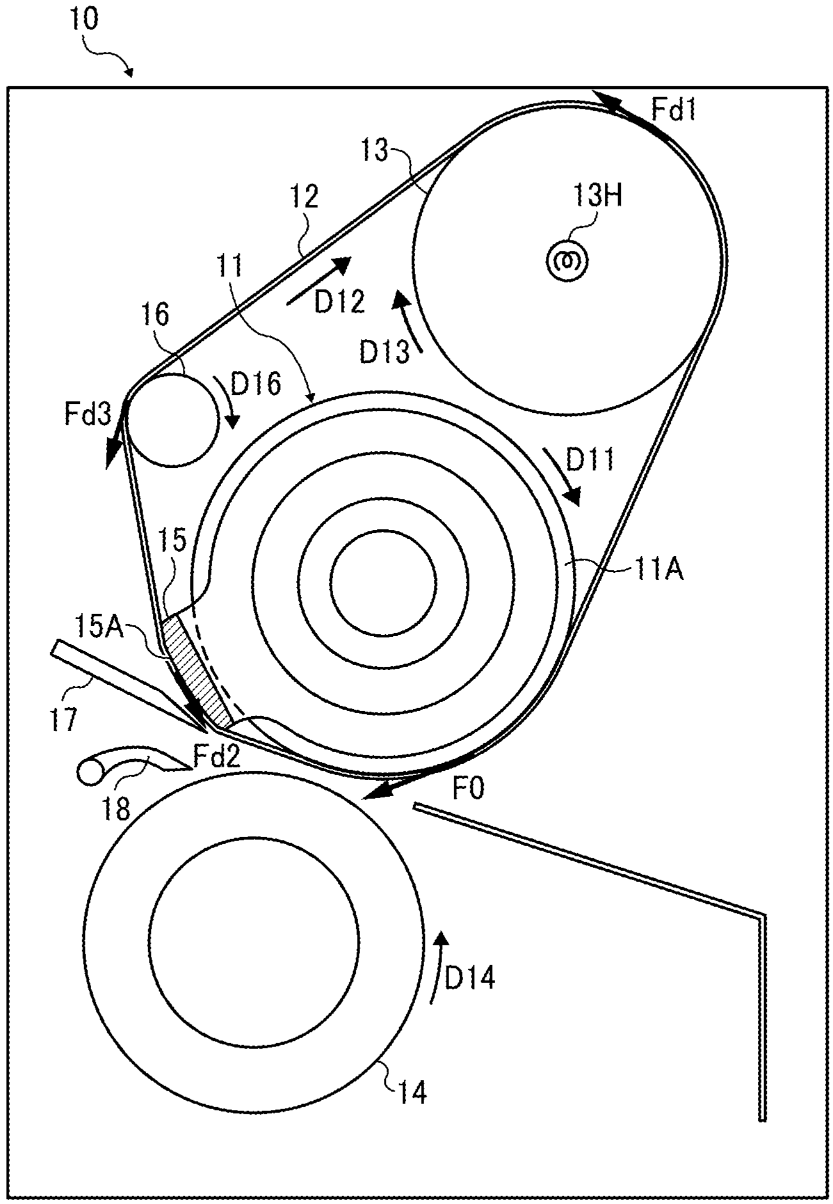
FIG. 2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F0
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D14
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FIG. 3

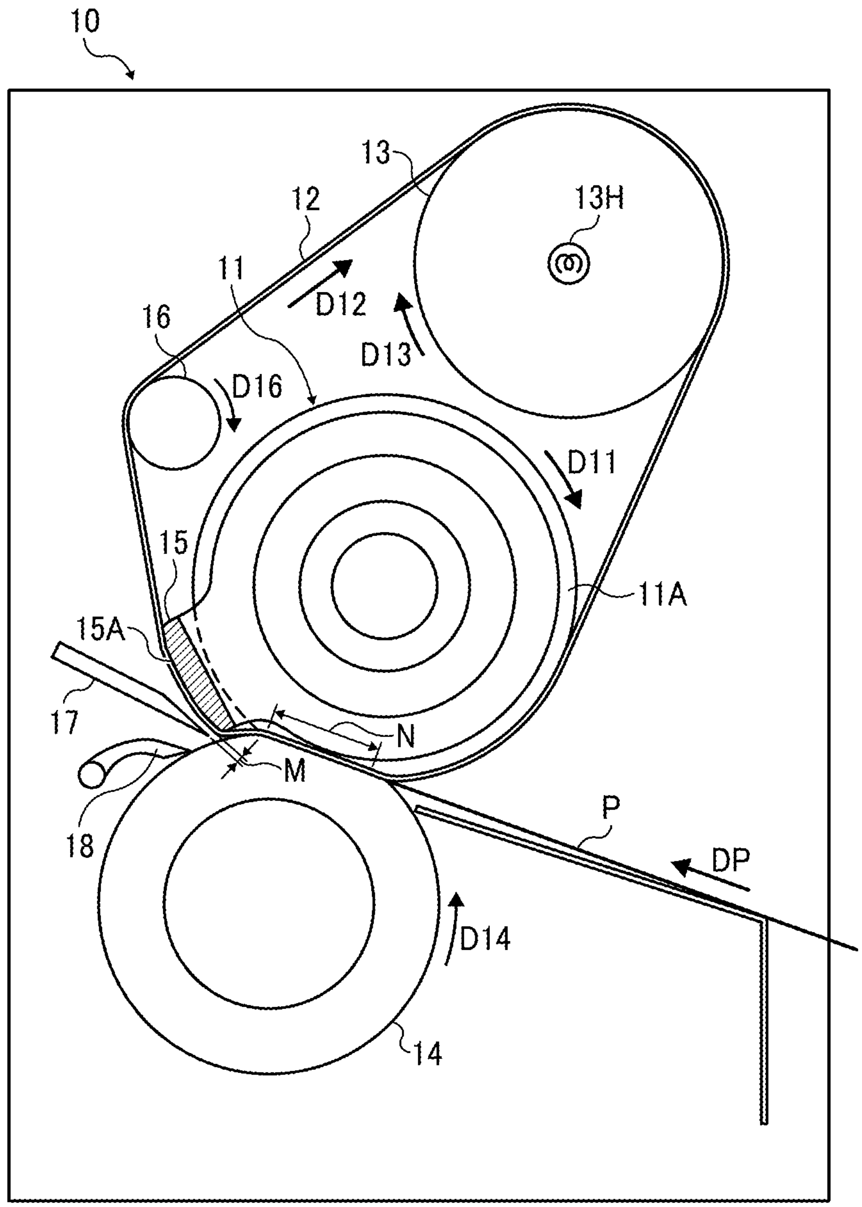
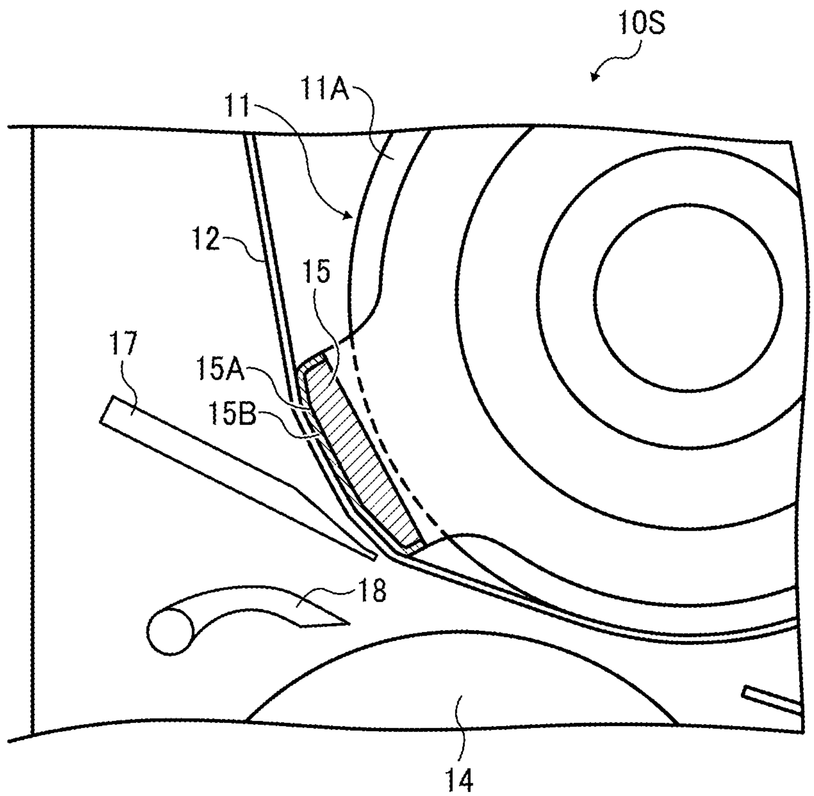


FIG. 4



FIXING DEVICE AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This patent application is based on and claims priority pursuant to 35 U.S.C. §119 to Japanese Patent Application No. 2014-047763, filed on Mar. 11, 2014, in the Japanese Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND

1. Technical Field

Example embodiments generally relate to a fixing device and an image forming apparatus, and more particularly, to a fixing device for fixing a toner image on a recording medium and an image forming apparatus incorporating the fixing device.

2. Background Art

Related-art image forming apparatuses, such as copiers, facsimile machines, printers, or multifunction printers having two or more of copying, printing, scanning, facsimile, plotter, and other functions, typically form an image on a recording medium according to image data. Thus, for example, a charger uniformly charges a surface of a photoconductor; an optical writer emits a light beam onto the charged surface of the photoconductor to form an electrostatic latent image on the photoconductor according to the image data; a developing device supplies toner to the electrostatic latent image formed on the photoconductor to render the electrostatic latent image visible as a toner image; the toner image is directly transferred from the photoconductor onto a recording medium or is indirectly transferred from the photoconductor onto a recording medium via an intermediate transfer belt; finally, a fixing device applies heat and pressure to the recording medium bearing the toner image to fix the toner image on the recording medium, thus forming the image on the recording medium.

Such fixing device may include a fixing roller, a heating roller, an endless fixing belt stretched taut across the fixing roller and the heating roller, and a pressure roller pressed against the fixing roller via the fixing belt to form a fixing nip between the fixing belt and the pressure roller. The fixing belt is rotated by the fixing roller and heated by a heater. As a recording medium bearing a toner image is conveyed through the fixing nip, the fixing belt and the pressure roller apply heat and pressure to the recording medium, melting and fixing the toner image on the recording medium.

SUMMARY

At least one embodiment provides a novel fixing device that includes an endless fixing belt rotatable in a predetermined direction of rotation, a first roller contacting the fixing belt and including a surface elastic layer to generate a rotation friction force between the fixing belt and the first roller to rotate the fixing belt, and a second roller contacting the fixing belt to exert a first inhibition force to the fixing belt in a direction opposite the direction of rotation of the fixing belt. The fixing belt is stretched taut across the first roller and the second roller. A pressure rotator is pressed against the first roller via the fixing belt to form a fixing nip between the fixing belt and the pressure rotator, through which a recording medium is conveyed. A separation aid is disposed downstream from the fixing nip in the direction of rotation of the fixing belt to decrease a curvature of the fixing belt and exert a second inhibition force to the fixing belt in the direction opposite the direction of rotation of the fixing belt. The second inhibition force is added to the first inhibition force to obtain a combined inhibition force that is smaller than the rotation friction force between the fixing belt and the first roller.

At least one embodiment provides a novel image forming apparatus that includes an image forming device to form a toner image and a fixing device, disposed downstream from the image forming device in a recording medium conveyance direction, to fix the toner image on a recording medium. The fixing device includes an endless fixing belt rotatable in a predetermined direction of rotation, a first roller contacting the fixing belt and including a surface elastic layer to generate a rotation friction force between the fixing belt and the first roller to rotate the fixing belt, and a second roller contacting the fixing belt to exert a first inhibition force to the fixing belt in a direction opposite the direction of rotation of the fixing belt. The fixing belt is stretched taut across the first roller and the second roller. A pressure rotator is pressed against the first roller via the fixing belt to form a fixing nip between the fixing belt and the pressure rotator, through which the recording medium is conveyed. A separation aid is disposed downstream from the fixing nip in the direction of rotation of the fixing belt to decrease a curvature of the fixing belt and exert a second inhibition force to the fixing belt in the direction opposite the direction of rotation of the fixing belt. The second inhibition force is added to the first inhibition force to obtain a combined inhibition force that is smaller than the rotation friction force between the fixing belt and the first roller.

Additional features and advantages of example embodiments will be more fully apparent from the following detailed description, the accompanying drawings, and the associated claims.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of example embodiments and the many attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic vertical sectional view of an image forming apparatus according to an example embodiment of the present disclosure;

FIG. **2** is a schematic vertical sectional view of a fixing device according to a first example embodiment incorporated in the image forming apparatus shown in FIG. **1**;

FIG. **3** is a schematic vertical sectional view of the fixing device shown in FIG. **2** illustrating a pressure roller pressed against a fixing roller; and

FIG. **4** is a partial vertical sectional view of a fixing device according to a second example embodiment.

The accompanying drawings are intended to depict example embodiments and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted.

DETAILED DESCRIPTION

It will be understood that if an element or layer is referred to as being “on”, “against”, “connected to”, or “coupled to” another element or layer, then it can be directly on, against, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, if an element is referred to as being “directly on”, “directly connected to", or "directly coupled to" another element or layer, then there are no intervening elements or layers present. Like numbers refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

Spatially relative terms, such as "beneath", "below", "lower", "above", "upper", and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, a term such as "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated **90** degrees or at other orientations) and the spatially relative descriptors used herein are interpreted accordingly.

Although the terms first, second, and the like may be used herein to describe various elements, components, regions, layers and/or sections, it should be understood that these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used only to distinguish one element, component, region, layer, or section from another region, layer, or section. Thus, a first element, component, region, layer, or section discussed below could be termed a second element, component, region, layer, or section without departing from the teachings of the present disclosure.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "includes" and/or "including", when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

In describing example embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, particularly to FIG. **1**, an image forming apparatus **200** according to an example embodiment is explained.

FIG. **1** is a schematic vertical sectional view of the image forming apparatus **200**. The image forming apparatus **200** may be a copier, a facsimile machine, a printer, a multifunction peripheral or a multifunction printer (MFP) having at least one of copying, printing, scanning, facsimile, and plotter functions, or the like. According to this example embodiment, the image forming apparatus **200** is a color copier that forms color and monochrome toner images on recording media by electrophotography. Alternatively, the image forming apparatus **200** may be a monochrome copier that forms monochrome toner images.

A description is provided of a construction of the image forming apparatus **200**.

As shown in FIG. **1**, the image forming apparatus **200** is a high speed, tandem color copier.

The image forming apparatus **200** includes an image forming device **200**A situated in a center portion of the image forming apparatus **200**, a sheet feeder **200**B situated below the image forming device **200**A, and an image reader situated above the image forming device **200**A.

A detailed description is now given of a construction of the image forming device **200**A.

The image forming device **200**A includes a fixing device **10** and a transfer belt **210** having a horizontally extending, transfer face.

An upper face of the transfer belt **210** is disposed opposite components that form toner images in complementary colors created based on separation colors. For example, photoconductors **205**Y, **205**M, **205**C, and **205**K, serving as image bearers that bear yellow, magenta, cyan, and black toner images in the complementary colors, respectively, are aligned along the transfer face of the transfer belt **210**.

Each of the photoconductors **205**Y, **205**M, **205**C, and **205**K is a drum rotatable counterclockwise in FIG. **1** in an identical direction. The photoconductors **205**Y, **205**M, **205**C, and **205**K are surrounded by an optical writing device **201**, chargers **202**Y, **202**M, **202**C, and **202**K, developing devices **203**Y, **203**M, **203**C, and **203**K, primary transfer devices **204**Y, **204**M, **204**C, and **204**K, and cleaners, respectively, which perform image formation processes as the photoconductors **205**Y, **205**M, **205**C, and **205**K rotate.

The developing devices **203**Y, **203**M, **203**C, and **203**K contain yellow, magenta, cyan, and black toners, respectively. The transfer belt **210** looped over a driving roller and a plurality of driven rollers is disposed opposite the photoconductors **205**Y, **205**M, **205**C, and **205**K and rotatable clockwise in FIG. **1**. A roller **211**, that is, one of the plurality of driven rollers, is disposed opposite a transfer roller **212** via the transfer belt **210**. A conveyance path extends horizontally from the transfer roller **212** to the fixing device **10** to convey a sheet P.

A detailed description is now given of a construction of the sheet feeder **200**B.

The sheet feeder **200**B includes a paper tray **220** that loads a plurality of sheets P serving as recording media and a feed device that separates an uppermost sheet P from other sheets P loaded in the paper tray **220** and conveys the sheet P to the transfer roller **212**.

A description is provided of a print job performed by the image forming apparatus **200** having the construction described above.

The charger **202**Y uniformly changes an outer circumferential surface of the photoconductor **205**Y. The optical writing device **201** forms an electrostatic latent image on the photoconductor **205**Y according to image data sent from the image reader. The developing device **203**Y containing yellow toner visualizes the electrostatic latent image into a yellow toner image. The primary transfer device **204**Y applied with a given bias primarily transfers the yellow toner image onto the transfer belt **210**.

Similarly, magenta, cyan, and black toner images are formed on the photoconductors **205**M, **205**C, and **205**K, respectively, and primarily transferred onto the transfer belt **210** successively by an electrostatic force such that the yellow, magenta, cyan, and black toner images are superimposed on a same position on the transfer belt **210**, thus forming a color toner image on the transfer belt **210**.

The roller **211** and the transfer roller **212** secondarily transfer the color toner image formed on the transfer belt **210** onto the sheet P conveyed from the paper tray **220**. The sheet P bearing the color toner image is conveyed further to the fixing device **10** where the color toner image is fixed on the sheet P as the sheet P passes through a fixing nip formed between a fixing belt and a pressure roller. The sheet P ejected from the fixing nip is conveyed onto a stacker **213** through an output path.

A description is provided of a construction of the fixing device **10** according to a first example embodiment.

FIG. **2** is a schematic vertical sectional view of the fixing device **10**. As shown in FIG. **2**, the fixing device **10** (a fuser or a fusing unit) includes a fixing roller **11** serving as a first roller having a surface elastic layer **11**A constituting an outer circumferential surface of the fixing roller **11**; a heating roller **13** accommodating a heater **13**H; an endless fixing belt **12** stretched taut across the fixing roller **11** and the heating roller **13** and heated by the heater **13**H through the heating roller **13**; a pressure roller **14** serving as a pressurization member or a pressure rotator disposed opposite the fixing roller **11** via the fixing belt **12**; a separation aid **15** disposed inside a loop formed by the fixing belt **12**; and a tension roller **16** that exerts tension to the fixing belt **12**.

FIG. **3** is a schematic vertical sectional view of the fixing device **10** illustrating the pressure roller **14** pressed against the fixing roller **11**. As shown in FIG. **3**, the fixing device **10** further includes a separator **17** and a separation claw **18** disposed downstream from a fixing nip N formed between the fixing belt **12** and the pressure roller **14** in a sheet conveyance direction DP. The separator **17** separates the sheet P from the fixing belt **12**. The separation claw **18** prevents the sheet P from being wound around the pressure roller **14**.

A detailed description is now given of a configuration of the fixing roller **11**.

The fixing roller **11** is constructed of a cored bar made of metal and the elastic layer **11**A coating the cored bar and made of silicone rubber. Alternatively, the elastic layer **11**A may be made of silicone rubber foam to reduce heat absorbed to the fixing belt **12** and thereby shorten a warm-up time to warm up the fixing belt **12** to a target temperature. As shown in FIG. **3**, as the pressure roller **14** is pressed against the fixing roller **11** via the fixing belt **12**, the elastic layer **11**A of the fixing roller **11** is elastically deformed to decrease an outer diameter of the fixing roller **11**. A driver drives and rotates the fixing roller **11** clockwise in FIG. **3** in a rotation direction D**11**.

A detailed description is now given of a configuration of the fixing belt **12**.

The fixing belt **12** is a double layered endless belt constructed of a base layer made of nickel, stainless steel, polyimide, or the like and an elastic layer made of silicone rubber or the like. The fixing belt **12** is stretched taut across the fixing roller **11** and the heating roller **13** with a given tension and rotatable in accordance with rotation of the fixing roller **11**. Thus, the fixing belt **12** rotates forward clockwise in FIG. **3** in a rotation direction D**12**.

A detailed description is now given of a configuration of the heating roller **13**.

The heating roller **13** is a hollow roller made of aluminum or iron and accommodating the heater **13**H (e.g., a halogen heater). Alternatively, the heater **13**H may be an induction heater (IH). The heating roller **13** is rotatable clockwise in FIG. **3** in a rotation direction D**13**. The heater **13**H heats the heating roller **13** to a given temperature (e.g., a fixing temperature appropriate to fix a toner image on a sheet P) that is detected by a thermistor. The heating roller **13** in turn heats the fixing belt **12**.

A detailed description is now given of a configuration of the pressure roller **14**.

The pressure roller **14** is a tube constructed of a cored bar made of aluminum, iron, or the like and an elastic layer coating the cored bar and made of silicone rubber or the like. A driver drives and rotates the pressure roller **14** counterclockwise in FIG. **3** in a rotation direction D**14**. A pressurization assembly separably presses the pressure roller **14** against the fixing roller **11** via the fixing belt **12**. For example, the pressurization assembly presses the pressure roller **14** against the fixing roller **11** via the fixing belt **12** and releases pressure between the pressure roller **14** and the fixing roller **11**. While the fixing device **10** is actuated, the pressure roller **14** is pressed against the fixing roller **11** via the fixing belt **12** with given pressure to form the fixing nip N between the pressure roller **14** and the fixing belt **12** as shown in FIG. **3**. Conversely, while the fixing device **10** is in a standby mode in which the fixing device **10** waits for a print job, the pressure roller **14** is isolated from the fixing belt **12** as shown in FIG. **2**.

According to this example embodiment, the pressure roller **14** is used as a pressurization member or a pressure rotator. Alternatively, an endless belt looped over a plurality of rollers (e.g., two rollers) may be used as a pressurization member or a pressure rotator.

A detailed description is now given of a configuration of the separation aid **15**.

As shown in FIG. **3**, the separation aid **15**, disposed downstream from the fixing nip N in the rotation direction D**12** of the fixing belt **12** or the sheet conveyance direction DP, projects from the outer circumferential surface of the fixing roller **11** radially. The separation aid **15** includes a contact face **15**A that contacts an inner circumferential surface of the fixing belt **12**. The contact face **15**A is coated with fluoroplastic to produce a smooth surface having a decreased kinetic friction coefficient. The separation aid **15** contacting the fixing belt **12** decreases a radius of curvature of the fixing belt **12** at a position downstream from the fixing nip N in the sheet conveyance direction DP.

A detailed description is now given of a configuration of the tension roller **16**.

The tension roller **16** is disposed downstream from the separation aid **15** and upstream from the heating roller **13** in the rotation direction D**12** of the fixing belt **12**. The tension roller **16** pressing against the inner circumferential surface of the fixing belt **12** exerts a desired tension to the fixing belt **12**. The tension roller **16** is rotatable in a rotation direction D**16**. Alternatively, the tension roller **16** may be disposed outside the loop formed by the fixing belt **12**.

A detailed description is now given of a configuration of the separator **17** and the separation claw **18**.

As shown in FIG. **3**, a slight gap M is provided between a front edge of the separator **17** and an outer circumferential surface of the fixing belt **12** to separate the sheet P from the fixing belt **12** at a position downstream from the fixing nip N in the sheet conveyance direction DP.

An oil applicator applies oil in a desired amount to the fixing belt **12** and the pressure roller **14**. The separator **17** and the separation claw **18** disposed downstream from the fixing nip N in the sheet conveyance direction DP or the rotation direction R**12** of the fixing belt **12** prevent the sheet P from being wound around the fixing belt **12** and the pressure roller **14**, ejecting the sheet P from a downstream section, that is, an exit, of the fixing nip N.

A description is provided of slackening of the fixing belt **12**.

In the fixing device **10** incorporating the components described above, as the fixing roller **11** rotates clockwise in FIG. **3** in the rotation direction D**11**, the fixing belt **12** rotates clockwise in the rotation direction D**12**. Simultaneously, the pressure roller **14** rotates counterclockwise in FIG. **3** in the rotation direction D**14**. When the outer circumferential surface of the fixing belt **12** is heated to a given temperature, a sheet P bearing an unfixed toner image is conveyed through the fixing nip N leftward in FIG. **3**. At the fixing nip N, the fixing belt **12** heated by the heater **13**H through the heating roller **13** and the pressure roller **14** apply heat and pressure to the sheet P, melting and fixing the toner image on the sheet P.

Thereafter, the sheet P bearing the fixed toner image is ejected from the fixing nip N. Since the separation aid **15** disposed downstream from the fixing nip N in the sheet conveyance direction DP decreases the radius of curvature of the fixing belt **12**, a leading edge of the sheet P separates from the fixing belt **12** readily. Thus, the sheet P separates from the fixing belt **12**. The leading edge of the sheet P is isolated from the fixing belt **12** by at least the slight gap M between the separator **17** and the fixing belt **12**.

As the rigid pressure roller **14** is pressed against the fixing roller **11** including the surface elastic layer **11**A at the fixing nip N, the elastic layer **11**A is elastically deformed, decreasing the outer diameter and an outer circumference of the fixing roller **11**. Accordingly, at the position downstream from the fixing nip N, the fixing belt **12** is slackened by an amount of decrease in the outer circumference of the fixing roller **11**.

Since the fixing belt **12** is stretched taut across the fixing roller **11** with a given tension, if the friction force between the fixing roller **11** and the fixing belt **12** is decreased to facilitate sliding of the fixing belt **12** over the fixing roller **11**, slack of the fixing belt **12** is eliminated. However, if the friction force between the fixing roller **11** and the fixing belt **12** is decreased, even when the fixing roller **11** rotates, motive power may not be transmitted from the fixing roller **11** to the fixing belt **12** readily, degrading rotation of the fixing belt **12**.

At the fixing nip N, the elastic layer **11**A is elastically deformed, decreasing the outer diameter and the outer circumference of the fixing roller **11**. Accordingly, at the position downstream from the fixing nip N in the sheet conveyance direction DP, the fixing belt **12** is slackened by an amount of decrease in the outer circumference of the fixing roller **11**. Since the contact face **15**A of the separation aid **15** projects from the outer circumferential surface of the fixing roller **11** radially, the fixing belt **12** is slackened in a portion thereof that contacts the contact face **15**A and a portion thereof that bridges the fixing roller **11** and the contact face **15**A.

A description is provided of a relation between a friction force FO and an inhibition force Fd.

As shown in FIG. **2**, the friction force F**0**, that is, a rotation friction force, generates between the fixing roller **11** and the fixing belt **12** as the fixing roller **11** rotates in the rotation direction D**11**. The inhibition force Fd is generated by the heating roller **13**, the separation aid **15**, and the tension roller **16** and exerted in a direction opposite the rotation direction D**12** of the fixing belt **12**.

The friction force F**0** generated between the fixing roller **11** and the fixing belt **12** is determined by a static friction coefficient and a tension of the fixing belt **12** when motive power, that is, a driving force, is transmitted from the fixing roller **11** to the fixing belt **12**. Conversely, the friction force FO generated between the fixing roller **11** and the fixing belt **12** is determined by a kinetic friction coefficient and a tension of the fixing belt **12** when motive power is not transmitted from the fixing roller **11** to the fixing belt **12**. In the fixing device **10** according to this example embodiment, motive power is transmitted from the fixing roller **11** to the fixing belt **12** and the friction force FO is determined based on a static friction coefficient $\mu 0$.

The static friction coefficient $\mu 0$ is not smaller than about 0.4, preferably not smaller than about 0.5. If the static friction coefficient $\mu 0$ is excessively small, it may be difficult to set the friction force FO to be greater than the inhibition force Fd.

A detailed description is now given of the inhibition force Fd generated as the halted fixing roller **11** starts rotation.

An inhibition force Fd**1** generated by the heating roller **13**, when the heating roller **13** rotates in the rotation direction D**13**, is defined as an addition of a rotation force Fr**1** to a kinetic friction force Fa**1**. The rotation force Fr**1** is determined by a radius, a whole mass distribution, and an acceleration of the heating roller **13**. The kinetic friction force Fa**1** generates at a rotation shaft of the heating roller **13**. When the heating roller **13** does not rotate, that is, when the fixing belt **12** slides over an outer circumferential surface of the heating roller **13**, the inhibition force Fd**1** is defined as a kinetic friction force Fs**1** generated between the fixing belt **12** and the heating roller **13**.

An inhibition force Fd**2** generated by the separation aid **15** is defined as a kinetic friction force Fs**2** generated between the fixing belt **12** and the contact face **15**A of the separation aid **15**.

An inhibition force Fd**3** generated by the tension roller **16**, when the tension roller **16** rotates in the rotation direction D**16**, is defined as an addition of a rotation force Fr**3** to a kinetic friction force Fa**3**. The rotation force Fr**3** is determined by a radius, a whole mass distribution, and an acceleration of the tension roller **16**. The kinetic friction force Fa**3** generates at a rotation shaft of the tension roller **16**. When the tension roller **16** does not rotate, that is, when the fixing belt **12** slides over an outer circumferential surface of the tension roller **16**, the inhibition force Fd**3** is defined as a kinetic friction force Fs**3** generated between the fixing belt **12** and the tension roller **16**.

In the fixing device **10** according to this example embodiment, the combined inhibition force Fd, that is, a total inhibition force, is defined as an aggregation of the inhibition forces Fd**1** to Fd**3**. When the fixing roller **11** starts rotation, the friction force FO generated between the fixing roller **11** and the fixing belt **12** is greater than the inhibition force Fd, transmitting motive power from the fixing roller **11** to the fixing belt **12** and therefore preventing sliding or slippage of the fixing belt **12**.

A detailed description is now given of an inhibition force Fd' generated as the number of rotations of the fixing roller **11** reaches a given value and the fixing roller **11** rotates at a constant speed.

An inhibition force Fd**1'** generated by the heating roller **13**, when the heating roller **13** rotates in the rotation direction D**13**, is defined as the kinetic friction force Fa**1** that generates at the rotation shaft of the heating roller **13**. When the heating roller **13** does not rotate, the inhibition force Fd**1'** is defined as the kinetic friction force Fs **1** that generates between the fixing belt **12** and the heating roller **13**.

An inhibition force Fd**2'** generated by the separation aid **15** is defined as the kinetic friction force Fs**2** generated between the fixing belt **12** and the contact face **15**A of the separation aid **15**.

An inhibition force Fd**3'** generated by the tension roller **16**, when the tension roller **16** rotates in the rotation direction D**16**, is defined as the kinetic friction force Fa**3** that generates at the rotation shaft of the tension roller **16**. When the tension roller **16** does not rotate, the inhibition force Fd**3'** is defined as the kinetic friction force Fs**3** generated between the fixing belt **12** and the tension roller **16**.

When the fixing roller **11** rotates at the constant speed, the combined inhibition force Fd', that is, a total inhibition force, is defined as an aggregation of the inhibition forces Fd**1**' to Fd**3**' and is smaller than the combined inhibition force Fd that generates when the fixing roller **11** starts rotation. Accordingly, when the fixing roller **11** starts rotation, motive power is transmitted from the fixing roller **11** to the fixing belt **12** and therefore motive power is also transmitted when the fixing roller **11** rotates at the constant speed.

The present disclosure is not limited to the example embodiments described above and various modifications are available as described below.

For example, according to the example embodiments described above, the contact face **15**A of the separation aid **15** is coated with fluoroplastic to produce a smooth surface. Alternatively, as shown in FIG. **4**, the contact face **15**A of the separation aid **15** may be coated with a smooth sheet **15**B. FIG. **4** is a partial vertical sectional view of a fixing device **10**S according to a second example embodiment that incorporates the smooth sheet **15**B. As shown in FIG. **4**, the smooth sheet **15**B made of fluoroplastic constitutes a surface of the separation aid **15** that contacts the inner circumferential surface of the fixing belt **12**. Alternatively, the contact face **15**A of the separation aid **15** may be treated with other surface processing that adjusts the friction force generated between the fixing belt **12** and the separation aid **15** to a desired value.

According to the example embodiments described above, the static friction coefficient between the fixing roller **11** and the fixing belt **12** is not smaller than about 0.5. Alternatively, the static friction coefficient between the fixing roller **11** and the fixing belt **12** may be set to other proper value that causes the friction force F**0** to be greater than the inhibition force Fd.

According to the example embodiments described above, the fixing device **10** incorporates the tension roller **16**. Alternatively, the tension roller **16** may be removed as long as the fixing belt **12** is exerted with proper tension.

A description is provided of advantages of the fixing devices **10** and **10**S.

As shown in FIGS. **2** to **4**, the fixing devices **10** and **10**S include the fixing roller **11** serving as a first roller including the surface elastic layer **11**A; the heating roller **13** serving as a second roller accommodating the heater **13**H; the endless fixing belt **12**, rotatable in a predetermined direction of rotation (e.g., the rotation direction D**12**), heated by the heater **13**H and stretched taut across the fixing roller **11** and the heating roller **13**; the pressure roller **14** serving as a pressure rotator pressed against the fixing roller **11** via the fixing belt **12** to form the fixing nip N between the fixing belt **12** and the pressure roller **14**; and the separation aid **15** disposed downstream from the fixing nip N in the direction of rotation of the fixing belt **12** to decrease a curvature of the fixing belt **12**. As the fixing roller **11** rotates the fixing belt **12** in the predetermined direction of rotation, a rotation friction force (e.g., the friction force F**0**) generated between the fixing roller **11** and the fixing belt **12** to rotate the fixing belt **12** is greater than an inhibition force exerted in a direction opposite the direction of rotation of the fixing belt **12**.

Since the separation aid **15** is situated downstream from the fixing nip N in the direction of rotation of the fixing belt **12**, if the fixing roller **11** is elastically deformed at the fixing nip N, the fixing belt **12** may be slackened at a position in proximity to the separation aid **15**. To address this circumstance, the kinetic friction coefficient between the separation aid **15** and the fixing belt **12** is adjusted to cause sliding or slippage of the fixing belt **12**, eliminating slack of the fixing belt **12** by tension exerted to the fixing belt **12**. It is not necessary to decrease the friction force between the fixing roller **11** and the fixing belt **12** to eliminate slack of the fixing belt **12**. The friction force is increased relative to the inhibition force to facilitate precise rotation of the fixing belt **12**.

The fixing belt **12** is slackened on the smooth contact face **15**A of the separation aid **15**. Accordingly, slack of the fixing belt **12** is eliminated by tension of the fixing belt **12**, decreasing the inhibition force Fd. The friction force FO generated between the fixing roller **11** and the fixing belt **12** is greater than the inhibition force Fd, facilitating precise rotation of the fixing belt **12**.

The separation aid **15** situated downstream from the fixing nip N in the rotation direction D**12** of the fixing belt **12** decreases the curvature of the fixing belt **12**, facilitating separation of the sheet P from the fixing belt **12**.

The contact face **15**A coated with fluoroplastic decreases the kinetic friction coefficient, eliminating slack of the fixing belt **12** readily and decreasing the inhibition force Fd further, which result in precise rotation of the fixing belt **12**.

The tension roller **16** places tension to the fixing belt **12**, facilitating elimination of slack of the fixing belt **12**. Further, the tension roller **16** increases the friction force F**0** generated between the fixing roller **11** and the fixing belt **12**, rotating the fixing belt **12** precisely.

According to the example embodiments described above, the fixing device **10** is installed in a tandem color copier serving as the image forming apparatus **200** as shown in FIG. **1**. Alternatively, the fixing devices **10** and **10**S may be installed in other image forming apparatuses, such as a copier, a facsimile machine, a printer, and a multifunction peripheral or a multifunction printer (MFP), that employ various methods.

According to the example embodiments described above, the fixing belt **12** serves as an endless fixing belt. Alternatively, a fixing film, a fixing sleeve, or the like may be used as an endless fixing belt. Further, the pressure roller **14** serves as a pressure rotator. Alternatively, a pressure belt or the like may be used as a pressure rotator.

The present disclosure has been described above with reference to specific example embodiments. Note that the present disclosure is not limited to the details of the embodiments described above, but various modifications and enhancements are possible without departing from the spirit and scope of the disclosure. It is therefore to be understood that the present disclosure may be practiced otherwise than as specifically described herein. For example, elements and/or features of different illustrative example embodiments may be combined with each other and/or substituted for each other within the scope of the present disclosure.

What is claimed is:

1. A fixing device comprising:

an endless fixing belt rotatable in a set direction of rotation;

a first roller contacting the fixing belt and including a surface elastic layer to generate a rotation friction force between the fixing belt and the first roller to rotate the fixing belt;

a second roller contacting the fixing belt to exert a first inhibition force to the fixing belt in a direction opposite the direction of rotation of the fixing belt, the fixing belt stretched taut across the first roller and the second roller;

a pressure rotator pressed against the first roller via the fixing belt to form a fixing nip between the fixing belt and the pressure rotator, through which a recording medium is conveyed; and

a separation aid disposed downstream from the fixing nip in the direction of rotation of the fixing belt to decrease a curvature of the fixing belt and exert a second inhibition force to the fixing belt in the direction opposite the direction of rotation of the fixing belt, the second inhibition force being added to the first inhibition force to obtain a combined inhibition force that is smaller than the rotation friction force between the fixing belt and the first roller,

wherein the separation aid projects from an outer circumferential surface of the first roller radially.

2. The fixing device according to claim **1**, wherein the separation aid includes a smooth contact face contacting an inner circumferential surface of the fixing belt.

3. The fixing device according to claim **2**, wherein the contact face of the separation aid is made of fluoroplastic.

4. The fixing device according to claim **2**, further comprising a smooth sheet coating the contact face of the separation aid and having a fluoroplastic surface that contacts the inner circumferential surface of the fixing belt.

5. The fixing device according to claim **1**, wherein the first inhibition force includes a first friction force between the second roller and the fixing belt and the second inhibition force includes a second friction force between the separation aid and the fixing belt.

6. The fixing device according to claim **1**, wherein a static friction coefficient between the first roller and the fixing belt is not smaller than about 0.5.

7. The fixing device according to claim **1**, further comprising a tension roller contacting the fixing belt to exert tension to the fixing belt.

8. The fixing device according to claim **7**, wherein the tension roller presses against an inner circumferential surface of the fixing belt.

9. The fixing device according to claim **7**, wherein the tension roller exerts a third inhibition force to the fixing belt in the direction opposite the direction of rotation of the fixing belt.

10. The fixing device according to claim **9**, wherein the third inhibition force includes a third friction force between the tension roller and the fixing belt.

11. The fixing device according to claim **1**, further comprising a heater disposed inside the second roller to heat the fixing belt through the second roller.

12. The fixing device according to claim **1**, further comprising a separator disposed downstream from the fixing nip in the direction of rotation of the fixing belt to separate the recording medium from the fixing belt.

13. The fixing device according to claim **1**, wherein the pressure rotator includes a pressure roller.

14. The fixing device according to claim **1**, wherein the separation aid is integrally formed with the first roller.

15. The fixing device according to claim **1**, further comprising a separator downstream from the fixing nip in the sheet conveyance direction.

16. The fixing device according to claim **15**, wherein a gap is provided between a front edge of the separator and an outer circumferential surface of the fixing belt.

17. The fixing device according to claim **1**, further comprising a separation claw downstream from the fixing nip in the sheet conveyance direction.

18. An image forming apparatus comprising:

an image forming device to form a toner image; and

a fixing device, disposed downstream from the image forming device in a recording medium conveyance direction, to fix the toner image on a recording medium,

the fixing device including:

an endless fixing belt rotatable in a set direction of rotation;

a first roller contacting the fixing belt and including a surface elastic layer to generate a rotation friction force between the fixing belt and the first roller to rotate the fixing belt;

a second roller contacting the fixing belt to exert a first inhibition force to the fixing belt in a direction opposite the direction of rotation of the fixing belt,

the fixing belt stretched taut across the first roller and the second roller;

a pressure rotator pressed against the first roller via the fixing belt to form a fixing nip between the fixing belt and the pressure rotator, through which the recording medium is conveyed; and

a separation aid disposed downstream from the fixing nip in the direction of rotation of the fixing belt to decrease a curvature of the fixing belt and exert a second inhibition force to the fixing belt in the direction opposite the direction of rotation of the fixing belt, the second inhibition force being added to the first inhibition force to obtain a combined inhibition force that is smaller than the rotation friction force between the fixing belt and the first roller,

wherein the separation aid projects from an outer circumferential surface of the first roller radially.

19. A fixing device comprising:

an endless fixing belt rotatable in a set direction of rotation;

a first roller contacting the fixing belt and including a surface elastic layer to generate a rotation friction force between the fixing belt and the first roller to rotate the fixing belt;

a second roller contacting the fixing belt to exert a first inhibition force to the fixing belt in a direction opposite the direction of rotation of the fixing belt,

the fixing belt stretched taut across the first roller and the second roller;

a pressure rotator pressed against the first roller via the fixing belt to form a fixing nip between the fixing belt and the pressure rotator, through which a recording medium is conveyed; and

a separation aid disposed downstream from the fixing nip in the direction of rotation of the fixing belt to decrease a curvature of the fixing belt and exert a second inhibition force to the fixing belt in the direction opposite the direction of rotation of the fixing belt, the second inhibition force being added to the first inhibition force to obtain a combined inhibition force that is smaller than the rotation friction force between the fixing belt and the first roller,

wherein the separation aid is spaced apart from the pressure rotator.

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